The Canadian Entomologist

Vol. LXXXIII Ottawa, Canada, May, 1951 No. 5

Identification of the Root Maggots (Diptera: Anthomyiidae) Attacking Cruciferous Garden Crops in Canada, with Notes on Biology and Control[1]

By A. R. Brooks[2]

Systematic Entomology, Dominion Entomological Laboratory
Saskatoon, Sask.

Introduction

A great number of papers and notes have been written on the root maggots attacking cabbage, cauliflower, turnip, and radish in Canada and the United States during the past 75 years. These deal chiefly with the occurrence, life-history, and control of the cabbage maggot, *Hylemya brassicae* (Bouché), or species which have been misidentified as that species. The Canadian work has followed the lead of Gibson and Treherne (1916), but in spite of the accumulation of information on the life-history of the species, on cultivation methods, and on insecticides, the pests of these cruciferous plants remain as noxious as ever.

During 1946 and 1947 an increased interest of Canadian entomologists in root maggots of garden crops, particularly in those attacking turnip, cabbage, and radish, resulted in the collection of much material from all parts of Canada. It soon became evident that a large number of dipterous species, of several different families, lived in the roots, some being phytophagous and causing damage, others being saprophagous and causing no damage. The results of the preliminary collection (Brooks, 1949) warranted further attempts to determine which species were damaging garden crops. Investigations during 1949 and 1950 resulted in the collection of additional species.

The present paper is designed to bring up to date only the general information that has been accumulated since 1946 about Canadian root maggots. In restricted localities or under particular climatic or soil conditions, detailed biological studies will perhaps reveal large variations in the activities of the species. Only after detailed studies have been made can one achieve an adequate control program.

Use of Names

The names of the species of *Hylemya* adopted in this paper are somewhat different from those used by Lundblad (1933) or Brooks (1949). A great deal of uncertainty exists in the application of the names *Hylemya cana* (Macq.), *Hylemya floralis* (Fall.), and *Hylemya florilega* (Zett.). Names about which there is little dispute have been used: *Hylemya cilicrura* (Rond.) [=*H. cana* Macq. of Brooks, 1949, and *H. fusciceps* (Zett.) of Lundblad, 1933]; *Hylemya trichodactyla* (Rond.) [=*H. floralis* (Fall.) of Brooks, 1949, and *H. florilega* Zett. of Lundblad, 1933]; *Hylemya crucifera* Huck. (apparently *H. floralis* Zett. of Lundblad, 1933).

The name *cabbage maggot* has long been applied to *Hylemya brassicae* (Bouché), but this species is no less active on radish, turnip, cauliflower, and other crucifers than it is on cabbage. Similarly, the turnip maggot, *H. crucifera*

[1]Contribution No. 2814, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

[2]Agricultural Research Officer.

Huck. [=*H. floralis* auct.], is not confined to turnip, nor the seed-corn maggot, *H. cilicrura* (Rond.), to seed corn.

Importance and Ecological Succession of Species

Nearly 30 species of Diptera have been collected from the roots of cruciferous plants in Canada since 1946.

Many of these species are scarce, and only a few appear to cause extensive damage to the plants. The presence of maggots in a damaged root does not necessarily indicate damage by root maggots. After the root is damaged, by attacks of phytophagous root maggots, by disease, or by mechanical injury, many phytosaprophagous species are attracted; as the process of decay progresses additional saprophagous species, predators, and parasites are lured to the root. The succession may result from many causes, and it cannot be assumed that like conditions prevail even for two adjacent plants.

The following list of Canadian species[3] is, on the whole, very similar to that given by Lundblad (1933) for Norway:—

Group I: Phytophagous species causing extensive root damage.

** *Hylemya brassicae* (Bouché)
** *Hylemya crucifera* Huck.
** *Hylemya planipalpis* (Stein)

Group II: Phytophagous or saprophagous species that may cause root damage under certain conditions but that are generally present only with members of Group I and in small numbers, occasionally being zoophagous.

** *Hylemya cilicrura* (Rond.)
** *Hylemya trichodactyla* (Rond.)
Hylemya fugax (Mg.)
Muscina assimilis (Fall.)
Muscina stabulans (Fall.)

Group III: Phytosaprophagous species that extend the damage caused by members of Groups I and II or by disease or mechanical injury.

* *Paragopsis strigatus* (Fall.)

Group IV: Phytosaprophagous or zoosaprophagous species.

* *Sciara* sp(p). (SCIARIDAE)
Cecidomyid species
* *Oscinella coxendix* (Fitch) (OSCINIDAE)
Leptocera sp. (BORBORIDAE)
Allophyla sp. (HELOMYZIDAE)
Lonchaea flavidipennis (Zett.) (LONCHAEIDAE)
Phorid species
* *Fannia canicularis* (L.) (ANTHOMYIIDAE)
Fannia scalaris (F.) (ANTHOMYIIDAE)
Musca domestica L. (MUSCIDAE)
Phaenicia sericata (Mg.) (CALLIPHORIDAE)
Calliphora vicina Desv. (CALLIPHORIDAE)
Sarcophaga sp. (SARCOPHAGIDAE)

Group V: Zoophagous species.

Psilocephala aldrichii Coq. (THEREVIDAE)
Thereva duplicis Coq. (THEREVIDAE)
Asilus sp. (ASILIDAE)
* *Platypalpus aequalis* LW. (EMPIDAE)
Dolichopus spp. (DOLICHOPODIDAE)
Phaonia sp. (ANTHOMYIIDAE)

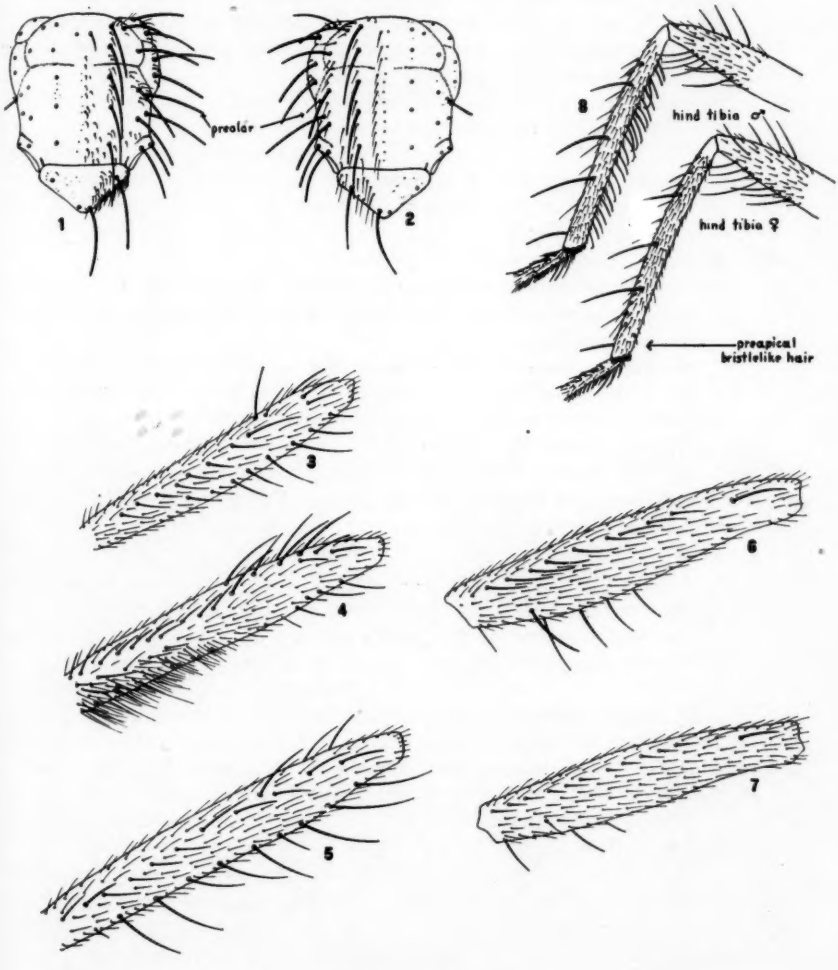
[3] **numerous and important species; *more than occasional records.

Identification of Dipterous Adults Reared from Cruciferous Roots

GROUPS I AND II

It is very important to determine the adults. Many of the eggs and the maggots are so similar that without long experience one cannot make accurate determinations from immature stages alone. On new host plants or in new localities rearing should always be done.

Most species present a rather distinctive macroscopic appearance in form and colour. However, the species of *Hylemya* are very similar; small and sometimes variable characters have to be used to distinguish the species.



FIGS. 1-9

1. *Hylemya brassicae*. Thorax of adult, dorsal aspect. 2. *H. cilicrura*. Thorax of adult, dorsal aspect. 3. *H. planipalpis*. Hind femur, male. 4. *H. brassicae*. Hind femur, male. 5. *H. crucifera*. Hind femur, male. 6. *H. brassicae*. Middle femur, female. 7. *H. crucifera*. Hind leg, female. 8. *H. cilicrura*. Hind leg, male. 9. *H. cilicrura*. Hind leg, female.

In examining the fly, one should consider the legs as extending at right angles to the body so that the anterior surface is in front, the posterior hindmost, the dorsal above, and the ventral lowermost.

The species of Groups I and II may be separated as follows:—

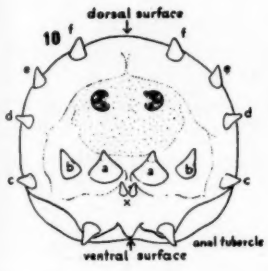
1. Third and fourth wing veins parallel at their apices; arista bare or pubescent
   - a. Anterior postsutural supraalar bristle (prealar) more than half as long as the following bristle (Fig. 1)
     - b. Males (holoptic)
       - c. Hind femur very hairy on the basal half of the anterior surface; hind femur with 3 or 4 bristles in a short row on the apical third of the anteroventral surface (Fig. 4) ... *Hylemya brassicae* (Bouché)
       - cc. Hind femur not very hairy; anteroventral row of bristles longer and with stronger bristles
         - d. Anteroventral row of bristles on the hind femur extending from the base to the apex, the bristles all strong (Fig. 5) ... *Hylemya crucifera* Huckett
         - dd. Anteroventral row of bristles on the hind femur extending only from about the centre to the apex, the bristles nearest the base shorter (Fig. 3) ... *Hylemya planipalpis* (Stein)
     - bb. Females (dichoptic)
       - c. Middle femur with a strong anteroventral bristle near the base, the ventral bristles strong; front femur with 3 to 6 small, erect bristles on the anterior surface (Fig. 6)
         - d. Front tibia with 1 posterior bristle ... *Hylemya planipalpis* (Stein)
         - dd. Front tibia with 2 posterior bristles ... *Hylemya brassicae* (Bouché)
       - cc. Middle femur without an anteroventral bristle or this very weak, the ventral bristles weak (Fig. 7); front femur usually without erect bristles on the anterior surface ... *Hylemya crucifera* Huckett
   - aa. Anterior postsutural supraalar bristle short and fine, less than half as long as the following bristle (Fig. 2)
     - b. Males (holoptic)
       - c. Hind tibia with a comb-like series of erect, bristle-like hairs along the entire length of the posteroventral surface (Fig. 8)
         - d. Basal segment of the middle tarsus with a row of long bristles dorsally, the bristles at least twice as long as the tarsal width ... *Hylemya trichodactyla* (Rondani)
         - dd. Basal segment of the middle tarsus with bristles that are shorter than the tarsal width ... *Hylemya cilicrura* (Rondani)
       - cc. Hind tibia without a complete series of erect hairs along the posteroventral surface; abdomen broad and flattened, with greenish-grey pollen; arista noticeably haired ... *Hylemya fugax* (Meigen)
     - bb. Females (dichoptic)
       - c. Arista noticeably haired especially toward the base, the hairs longer than the width of the arista; abdomen subshining, greenish with only thin pollen ... *Hylemya fugax* (Meigen)
       - cc. Arista not noticeably haired; abdomen grey or yellowish-grey with a darker central line dorsally
         - d. Hind tibia with 1 (or 2) pre-apical bristle-like hair on the posteroventral surface (Fig. 9) ... *Hylemya cilicrura* (Rondani)
         - dd. Hind tibia without a pre-apical bristle-like hair on the posteroventral surface ... *Hylemya trichodactyla* (Rondani)

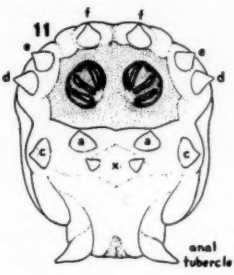
2. Fourth vein bent forward near the apex; arista plumose
   a. Legs and palpi black; abdomen bluish-grey.....*Muscina assimilis* (Fallen)
   aa. Legs and palpi partly or wholly reddish-yellow; abdomen greyish-yellow.... *Muscina stabulans* (Fallen)

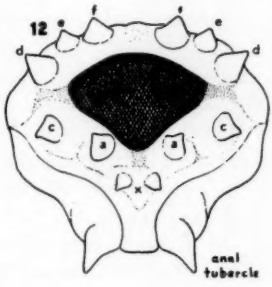
Identification of Dipterous Larvae in Cruciferous Roots

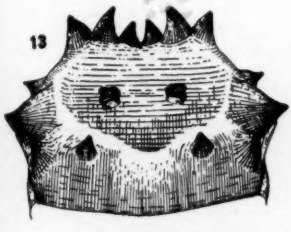
GROUPS I AND II

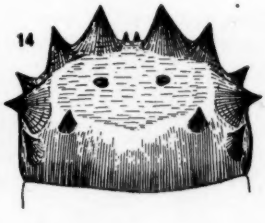
There are three instars, each of which has morphological characteristics. The three may be separated as follows:—

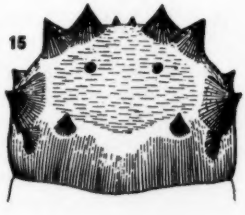


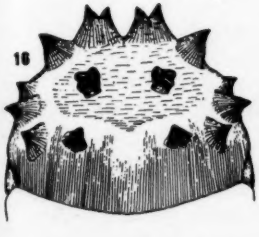


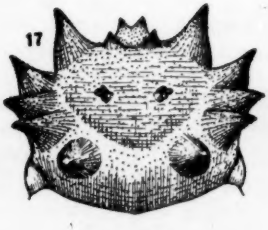


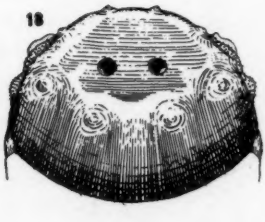












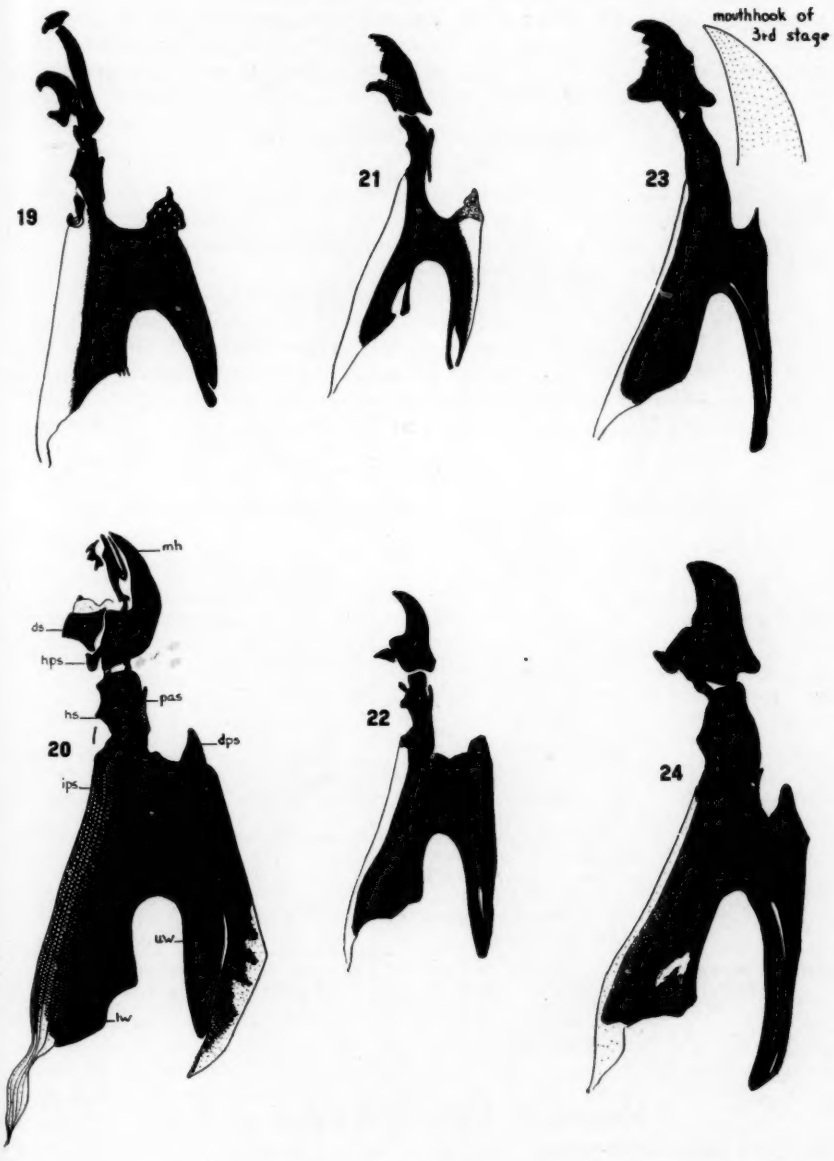
FIGS. 10-18

10. *Hylemya* sp. Posterior aspect of maggot showing tubercles. 11. *Calliphora* sp. Posterior aspect of maggot showing tubercles. 12. *Sarcophaga* sp. Posterior aspect of maggot showing tubercles. 13-18. Apical segment of mature maggot, dorsal aspect. 13. *Hylemya cruciferа.* 14. *H. trichodactyla.* 15. *H. cilicrura.* 16. *H. brassicae.* 17. *H. fugax.* 18. *Muscina assimilis.*

The *first-instar larva* has posterior spiracles only; the mouth parts consist of one median hook, and a paired plate on each side. The *second-instar larva* has anterior and posterior spiracles, the posterior spiracles possessing two slits; the mouth hooks are large and paired, usually with a number of small teeth below. The *third-instar larva* has anterior and posterior spiracles, the posterior spiracles possessing three slits; the mouth hooks are large and paired, usually smooth below. The *moulting phase* takes considerable time, and many individuals will show characteristics of two stages; this is most conspicuous in the mouth parts, and specimens apparently with four mouth hooks instead of two should be determined with this in mind.

The species of Groups I and II may be separated as follows:—

1. Larvae of each instar without conspicuous apical tubercles; instar I with oral cuticular spines; anterior spiracles of instars II and III with 5 or 6 divisions; mouth parts of instars II and III with many narrow accessory sclerites (Figs. 18, 26, 19, 20) ..... *Muscina assimilis* (Fallen)
2. Larvae of each instar with apical tubercles; mouth parts of instars II and III without accessory sclerites
   a. First-instar larvae
      b. Larvae with oral cuticular spines; prestomal and ectostomal sclerites small and united; labial sclerite and mouth parts slender (Fig. 30) ..... *Hylemya cilicrura* (Rondani) or *H. trichodactyla* (Rondani)
      bb. Oral cuticular spines absent
         c. Prestomal and ectostomal sclerites reduced to a single pair of hooks; larval skin spinose; mouth parts slender (Fig. 32) ..... *Hylemya fugax* (Meigen)
         cc. Prestomal and ectostomal sclerites large and separated; mouth parts robust; larval skin not spinose (Fig. 28) ..... *Hylemya brassicae* (Bouché), *H. crucifera* Huckett, or *H. planipalpis* (Stein)
   aa. Second- and third-instar larvae
      b. Tubercle *x* large and bifid at the apex; tubercle *a* small; cuticle with small spines (Fig. 17) ..... *Hylemya fugax* (Meigen)
      bb. Tubercles *x* small and separate, or absent; tubercle *a* large; cuticle without spines.
         c. Slit in the upper wing of the pharyngeal sclerite short and wide; posterior spiracular plate without a button; anterior spiracle with 6 to 8 divisions
            d. Maggot slender and with a thin body wall, the larval food generally showing pinkish through the body wall; tubercles *a* and *b* long, triangular, generally contiguous at their base, tubercle *a* being the broader and longer (Fig. 14) ..... *Hylemya trichodactyla* (Rondani)
            dd. Maggot robust, with a thicker body wall so that the food material is not visible; tubercles *a* and *b* short, triangular, and approximately equal in size (Fig. 15) ..... *Hylemya cilicrura* (Rondani)
         cc. Slit in the upper wing of the pharyngeal sclerite long and slender (Figs. 23, 24); tubercle *a* bifid; tubercle *x* absent; posterior spiracular plate with a button; anterior spiracles with 8 to 12 divisions
            d. Tubercle *a* divided, the inner division being smaller and usually appearing as a separate tubercle (Fig. 13) ..... *Hylemya crucifera* Huckett



FIGS. 19-24

19-20. *Muscina* sp. Mouth parts. 19. Second-instar. 20. Third-instar; dps, dorsopharyngeal; ds, dentate; hps, hypopharyngeal; hs, hypostomal; ips, infrapharyngeal; lw, lower wing of pharyngeal; mh, mouth hook; pas, parastomal; uw, upper wing of pharyngeal. 21-22. *Hylemya cilicrura*. Mouth parts. 21. Second-instar. 22. Third-instar. 23-24. *H. brassicae*. Mouth parts. 23. Second-instar. 24. Third-instar.

dd. Tubercle *a* only partly divided (Fig. 16)
e. On radish in the Prairie Provinces and British Columbia..... *Hylemya planipalpis* (Stein)
ee. On all cruciferous hosts, including radish, except in the Prairie Provinces ..... *Hylemya brassicae* (Bouché)

Identification of Dipterous Eggs

GROUPS I AND II

1. Eggs with a pair of large, sled-like wings on the ventral surface; dorsal chorion with no definite pattern (Fig. 25)..... *Muscina assimilis* (Fallen)
2. Eggs without large, sled-like wings on the ventral surface
   a. Dorsal surface with a hexagonal pattern
      b. Ventral surface with a groove along the entire length (Fig. 31)..... *Hylemya fugax* (Meigen)
      bb. Ventral surface with only a shallow groove on the anterior third (Fig. 29)..... *Hylemya cilicrura* (Rondani) or *H. trichodactyla* (Rondani)
   aa. Dorsal chorion appearing ridged; ventral surface with a groove (Fig. 27).... *Hylemya brassicae* (Bouché), *H. crucifera* Huckett, or *H. planipalis* (Stein)

TABLE I

PLANT HOSTS, OCCURRENCE, AND GEOGRAPHICAL DISTRIBUTION OF THE SPECIES OF GROUP I IN CANADA

Pest Species	Distribution	Occurrence	Hosts
Hylemya brassicae (Bouché)	B.C.: Agassiz, Victoria, Tappen Alta: Edmonton Ont.: general Que.: general N.B.: general N.S.: general P.E.I.: general Nfld.: general	throughout the season 3 to 5 generations	all cultivated crucifers and many wild species
Hylemya crucifera (Huckett)	B.C.: Quesnel Alta.: Edmonton, Peace River, Lethbridge Sask.: Saskatoon, White Fox, Regina, Lac la Ronge, Indian Head Man.: Brandon, Dauphin Que.: Ft. George	from July 1 1 to 1½ generations	all cultivated crucifers and many wild species
Hylemya planipalpis (Stein)	B.C.: Victoria Alta: Tofield, Grimshaw Sask.: White Fox, Saskatoon Man: Brandon, Awcme, Dauphin	throughout the season 3 to 5 generations	radish; *Descurainia richardsonii* (Sweet) Schultz

Notes on the Species of Groups I and II

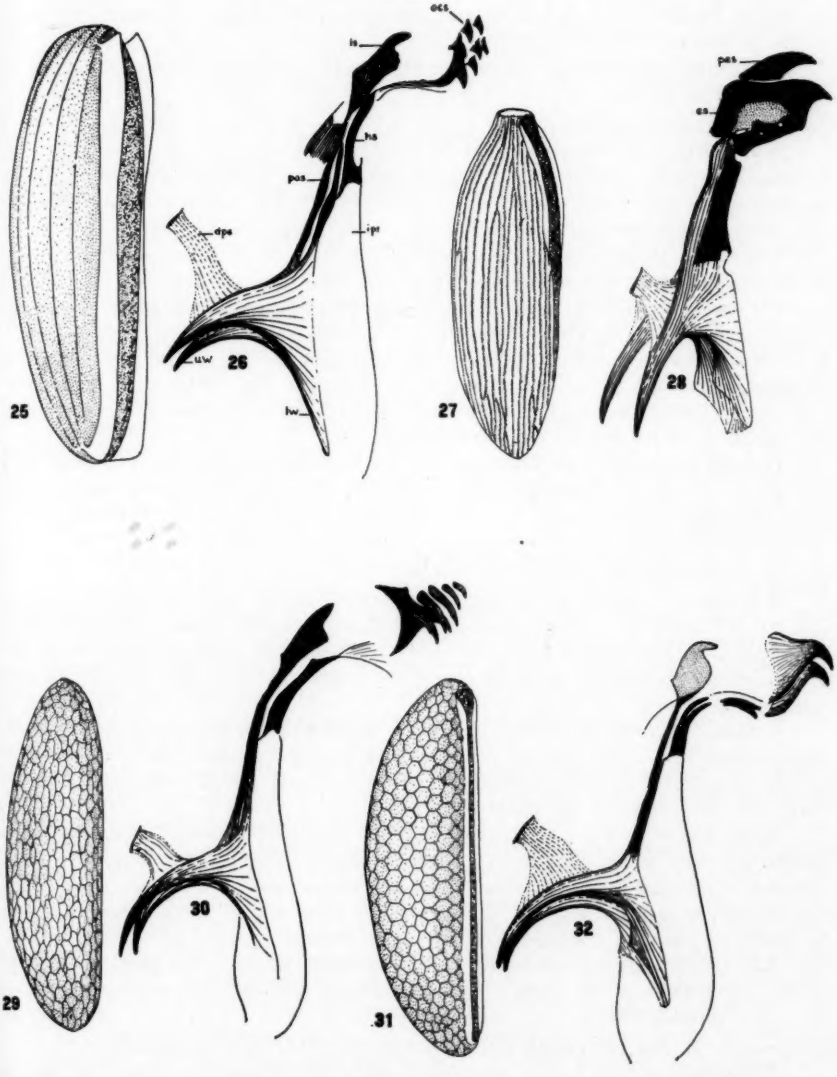
Hylemya brassicae (Bouché)

This species is the major pest of radish, turnip, cabbage, and other cruciferous garden crops in British Columbia and from Ontario to Newfoundland. There are a number of generations, and all stages of the species from the egg to the adult may be found throughout the season from April until October, the generations having a very wide overlap.

H. brassicae lays its eggs chiefly on the stem at the soil level, occasionally slightly below the soil level to an inch or so above, or on the petioles of the

lower leaves. The eggs are generally found in clumps of a few to a hundred or more, and it is evident that more than one female will oviposit at the same spot.

This species damages chiefly the roots and the stem, but under some conditions the maggots work their way into the heads of cauliflower and brussels sprouts, causing browning and rotting.



FIGS. 25-32

25-26. *Muscina assimilis*. 25. Egg. 26. Mouth parts of first instar; dps, dorsopharyngeal; hs, hypostomal; ips, infrapharyngeal; ls, labial; lw, lower wing of pharyngeal; ocs, oral cuticular spines; pas, parastomal; uw, upper wing of pharyngeal. 27-28. *Hylemya brassicae*. 27. Egg. 28. Mouth parts of first instar; es, ectostomal; pes, prestomal. 29-30. *H. cilicrura*. 29. Egg. 30. Mouth parts of first instar. 31-32. *H. fugax*. 31. Egg. 32. Mouth parts of first instar.

The maggots cause damage by mining and burrowing; the root damage is evident from an external examination; the head injury, when present, is not noticeable from the outside. When the plants are small, five to 10 maggots are sufficient to kill the plant, but later in the season a population of 100 or more maggots can be supported if the plant is healthy and has sufficient water.

Damage to cabbage and cauliflower is severe early in the season. Damage to turnip and radish is severe at any time, for a few maggots render the root unfit for the market.

A detailed account of this species in Canada has been presented by Gibson and Treherne (1916).

Hylemya crucifera Huckett

This species is the major pest of turnip, cabbage, and cauliflower in the Prairie Provinces, especially in the wooded and parkland sections. There appears to be only one generation a year under normal weather conditions, the flies appearing early in July and the eggs and maggots becoming numerous in the latter half of July and in August. Eggs can be found until September, indicating a long period of emergence of the flies.

H. crucifera lays its eggs in clumps in the same situations as *H. brassicae*, but does not appear to attack radish to any extent. The maggots cause damage by mining and burrowing, never penetrating very deeply into the cortex; the damage is readily observable externally. Though the species has not been collected from the heads of cauliflower or brussels sprouts, it occasionally works its way into the petioles of the lower leaves.

Garden crops are well developed by the time the maggots become large and numerous, so that the damage to cauliflower and cabbage is not severe unless more than 80 maggots are present in one root, other conditions being favourable for plant growth.

Hylemya planipalpis (Stein)

This species appears to be the major pest of radish in the Prairie Provinces and has not been taken from other cultivated crops in this region. In California, cabbage, cauliflower, and turnip are also attacked. In Saskatchewan there are a number of generations and the species is present in all stages throughout the season.

Unlike *H. brassicae* or *H. crucifera*, *H. planipalpis* lays its eggs singly or in twos and threes. The eggs are placed on the exposed portion of the radish root or on the leaf petioles, often being placed on the inner side of the petiole, where they are not noticeable on casual examination.

Upon hatching, the first-stage larva bores into the radish and thereafter stays within the root, gradually tunnelling out the flesh. The damage is not apparent externally and can only be found when the root is cut.

Radish is rarely killed by this species, as only one to three maggots occur in each root; but the tunnelling causes much damage.

The first generation of the flies emerges about June 15, the pupation period being approximately ten days. The generations have a wide overlap if radish is grown continuously.

Hylemya cilicrura (Rondani) and *Hylemya trichodactyla* (Rondani)

These species can be distinguished from each other for certain only in the adult male, the key character given for the female and for the maggot being somewhat variable (Huckett, 1921). The two species appear to have similar life-cycles and occur on many hosts other than cruciferous plants. *H. cilicrura* has a widespread distribution in Canada, and *H. trichodactyla* has been collected in Ontario, Quebec, and the Maritime Provinces and at Dawson, Yukon.

These species have been collected from roots of cruciferous plants already infested by one of the species of Group I or from plants already damaged through other causes. The maggots occur in the tunnels made by *H. brassicae* or *H. crucifera* and normally form about 10 per cent of the population.

The eggs are laid in small clumps on the stems or leaf petioles, much in the same manner as for *H. brassicae*, but usually somewhat higher on the stem and in smaller numbers; the eggs are often found among groups of eggs of other species.

On cruciferous plants the maggots begin to appear late in June, becoming common in August. After the middle of September, very few specimens of *cilicrura* or *trichodactyla* can be found on these hosts. There appear to be two or three generations in the roots.

Miles (1948, 1950) has given a detailed account of these species in Britain.

Hylemya fugax (Meigen)

This species has been collected from cruciferous plants only a few times during the years 1947-50. In Prince Edward Island it was found twice during 1948: on a cauliflower root in July and on a dry-rotted turnip root in October. At Agassiz, B.C., the species occurred with *H. brassicae* in brussels sprouts in June and October, 1949. Eggs were taken in abundance from cabbage leaves in Newfoundland in 1949 and in July, 1950. A few specimens were taken from turnip roots in Newfoundland in September and October, 1950.

According to Miles (1950) the species is saprophytic and occurs with other larvae. The eggs are laid singly or in small batches on leaves or cut and broken stems. There are three to five generations each season, each generation taking four to five weeks.

Many hosts are attacked.

Muscina assimilis (Fallen) and *Muscina stabulans* (Fallen)

These species have similar habits; and although they are present in cruciferous roots in every region in Canada they generally form a very insignificant part of the population (*M. stabulans* is very rarely taken). When present in a pure population on undamaged plants, the maggot makes a shallow, winding burrow similar to a very superficial burrow formed by *H. brassicae*.

The eggs are apparently laid singly in the soil around the plant in June. The maggots are mature by the end of July.

Muscina spp. are sometimes parasitic; they have been reared from various lepidopterous larvae, and it is evident that these species are very like *Hylemya cilicrura* in habits, that is, omnivorous.

Keilin (1917) has described the larvae and reviewed the habits of *M. assimilis* and of *M. stabulans*.

Notes on Control

As the three primary species have somewhat different biologies, and cause different types of damage (especially *H. planipalpis*), it appears possible that each of these will react differently to control measures such as the use of insecticides or cultivation methods. The general biology appears to indicate that effective control of the phytophagous species on turnip, radish, young cabbage, and young cauliflower (where few maggots may cause extensive damage) will depend on control of pupae, adults, eggs, or first-instar larvae. On well-developed cabbage and cauliflower it may be possible to arrive at a suitable control of the older maggots in the root.

In the material examined there was no indication that parasites or predators offered any possibility for control, these forms occurred only in small numbers; they generally killed the latter-stage maggots or the pupae, after the damage was

done. Because of their small numbers they do not appear to be an effective means for limiting the adult population.

Summary

Three species of *Hylemya*, namely, *brassicae* (Bouché), *crucifera* Huckett, and *planipalpis* (Stein), cause extensive damage to the roots of cruciferous garden plants in Canada. A number of other species, notably *H. cilicrura* (Rondani) and *H. trichodactyla* (Rondani), may be very abundant under certain conditions but do not normally attack healthy roots.

The three primary species have different life-histories and distributions, and cause different types of damage. It is essential, therefore, to establish the identity of the species involved.

A number of saprophagous species may become established in roots after damage has been caused by the phytophagous species, disease, or mechanical injury. It cannot be assumed that the presence of maggots in a root means that the maggots have caused the damage.

It appears possible that no one control method will be found effective against all species, or against one species in different host plants or at different times of the year.

Parasites and predators appeared to be insignificant as a means of reducing the root maggot population.

Acknowledgments

This investigation was made possible by officers of Field Crops Insect Investigations, Division of Entomology, throughout Canada. I wish to express my appreciation to all these officers and especially to Mr. F. M. Cannon, Charlottetown, Prince Edward Island, for his extensive collections; to Mr. W. G. Matthewman, Ottawa; and to Mr. W. W. A. Stewart, Saskatoon, who provided much of the information on *Hylemya crucifera* Huck. and *H. planipalpis* (Stein).

Select Bibliography

Brooks, A. R. 1949. The identification of the commoner root maggots of garden crops in Canada. *Canada, Dept. Agr., Div. Ent. mimeographed pamphlet.*

Gibson, A., and R. C. Treherne. 1916. The cabbage root maggot and its control in Canada with notes on the imported onion maggot and the seed-corn maggot. *Canada, Dept. Agr., Ent. Bull.* 12.

Huckett, H. C. 1924. A systematic study of the Anthomyiinae of New York, with especial reference to the male and female genitalia. *Cornell Univ. Agr. Expt. Sta. Mem.* 77: 3-91.

Keilen, D. 1917. Recherches sur les Anthomyides à larves carnivores. *Parasitology* 9: 325-450.

Lundblad, C. 1933. Kalflugorna. *Statens Vaxtskyddsanstalt Middelande* 3: 1-103.

Miles, M. 1948. Field observations on the bean seed fly (seed corn maggot), *Chortophila cilicrura* Rond., and *C. trichodactyla* Rond. *Bull. Ent. Res.* 38: 559-574.

Miles, M. 1950. Studies of British anthomyiid flies. *Bull. Ent. Res.* 41: 343-354.

Schoene, W. J. 1916. The cabbage maggot: its biology and control. *New York Agr. Expt. Sta. Bull.* 416: 99-160.

Slingerland, M. V. 1894. The cabbage root maggot, with notes on the onion maggot and allied insects. *Cornell Univ. Agr. Expt. Sta. Bull.* 78: 481-547.

The American Species of *Phratora* Chev. (Coleoptera: Chrysomelidae)[1]

By W. J. Brown[2]
Systematic Entomology, Division of Entomology
Ottawa, Canada

This paper offers a taxonomic treatment of the American species belonging to the genus properly known as *Phratora* but designated as *Phyllodecta* Kby. by recent authors. *Phyllodecta* was described by Kirby in 1837 (p. 216); the month of publication is given as October by Sherborn (1929, p. 4931), and, according to Westwood (1837), Kirby's volume was presented on November 6 to the monthly meeting of the Entomological Society of London. *Phratora* has been attributed to Redtenbacher, because he was the first to publish the name with a description of generic characters, and has been dated 1845 (p. 116) or 1849 (p. 554). *Phratora* Redt., lacking priority, has been considered a synonym of *Phyllodecta* Kby. However, in 1837 both Chevrolat (p. 405 or 429) and Faldermann (p. 363) used *Phratora* in ways that would validate the name; Chevrolat's usage, and possibly that of Faldermann, antedates Kirby's description of *Phyllodecta*. Chevrolat listed previously described species in *Phratora*, and his usage, as shown by Barber and Bridwell (1940, p. 4), was published between March 1 and July 5, 1837. Faldermann, without comment on the genus, described a new species in *Phratora*, but the exact date of his publication is unknown. The species considered by all these authors are congeneric. A consideration of genotypes is impractical at this time, but such is not required to show that the genus should be known as *Phratora* and that *Phyllodecta* is a synonym.

The American species of *Phratora* have been very poorly known. The earliest mention of them appears to be Kirby's reference in 1837 (p. 216) of American specimens to *vitellinae* (L.), a European species. Suffrian in 1858 (p. 394) referred American specimens to the European species *vulgatissima* (L.). Consequently these two European names have been included in American lists, and they were the only names applied to specimens in American collections until Schaeffer described *americana* and its "variety" *pallipes* in 1928. All American species have been confused with *americana* since the latter was described, except for *aklaviki* (Carr), which was described in 1932. Mannerheim described *interstitialis* in 1853; the species remains unknown except for the original description, but it is probably synonymous with *aklaviki*. *Phytodecta scutellaris* Sahlb., associated with the species of *Phratora* in some American lists, belongs to *Phytodecta* Kby. The present paper recognizes five species, including *americana* and *aklaviki*, and three subspecies. There is no evidence that any European species occurs in America.

The natural history of *Phratora* has received no attention in America. The genus is holarctic. In America it is transcontinental and occurs from the northern limit of trees to the northern tier of states; it avoids the western plains and extends southward in and near the mountains to Wyoming and Georgia. The species appear to have similar life-histories. They restrict their feeding to willows and poplars. The adults hibernate and appear on the food-plants in May or June, depending on latitude and weather. Egg-laying is completed in mid-June in southern Ontario and a month later in central Manitoba. The eggs are about twice as long as wide and are bluntly rounded at each end. They are

[1]Contribution No. 2791, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.
[2]Agricultural Research Officer.

placed on the undersides of the leaves and are deposited on their sides in two contacting rows to form distinctive, compact masses of 12 to 18 eggs. The larvae are gregarious; they feed on the undersides of the leaves with their bodies in contact, and they do not eat the upper epidermis. The larvae pupate in the soil, and the adults of the new generation appear on the food-plants in late summer. There is a single generation each year, and there appears to be no parthenogenesis. The adults have gregarious tendencies; the colonies are often populous but may be remarkably rare.

In the American species, the body above is metallic, usually strongly so, and immaculate. The underside is blackish and feebly metallic, but the apical ventral segment is pale on each side. The legs are blackish or bicoloured and are usually feebly metallic. The antennae are black and have the basal segments, only the first and second in most specimens, partly pale. In all species, the head may or may not have a feeble impression between the eyes on the median line, and the pronotum varies somewhat in form. The pronotal sides are more or less parallel except apically, and the pronotum is not wider before the middle than at the base except in some specimens of the more robust species. The first segment of each tarsus is much wider than the second in the male, scarcely wider than the second in the female, and the antennae are more elongate in the male. The copulatory organ of the male is a curved tube containing, in its internal sac, a complex armature. The armature consists of articulating rods on each side of the median orifice, which is subapical and dorsal, and a variety of more or less sclerotized and contorted parts. In a cleared preparation, the armature, with its parts superimposed, is visible through the transparent copulatory organ. The figures and descriptions of this paper were made from such preparations, from organs mounted on slides in Canada balsam.

The present study is based largely on material in the Canadian National Collection. Some material has been examined in the collections of Ohio State University, Cornell University, the American Museum of Natural History, and the United States National Museum. To the curators of these institutions, and to Messrs. C. A. Frost of Framingham, Mass., and G. Stace Smith of Creston, B.C., the writer extends appreciation for the kindnesses received. The material from Newfoundland and James Bay, and most of that from central Manitoba and northwestern Canada, was collected in the Northern Insect Survey, which is a co-operative project of the Canada Department of Agriculture and the Defence Research Board, Canada Department of National Defence.

Key to Species and Subspecies

1. Anterior margins of antennal segments four to six with a fringe of long hairs in males and some females. Males with the first segments of all tarsi equally dilated 2

   Antennal segments four to six lacking long hairs, except near their apices, in both sexes. Males with the first segment of each hind tarsus two-thirds as wide as, of each front and middle tarsus three-fourths as wide as, the third segment 6

2. Lateral declivities of the elytra very irregularly punctate, usually with the striae not or scarcely traceable. Blue-green, blue, or green above. Male with the first segment of each tarsus subequal in width to the third segment. Female with a fringe of long hairs on the anterior margins of antennal segments four to six. British Columbia and northward ..... 1. *aklaviki* (Carr)

   Lateral declivities of the elytra less irregularly punctate, the striae usually defined. Males with the first segment of each tarsus about three-fourths

as wide as the third segment. Females lacking, or virtually lacking, long hairs except apically on antennal segments four to six 3

3. Purple or coppery above. Internal sac of male copulatory organ lacking large teeth. Feeding on *Populus* and *Salix* 4
Colour above variable. Internal sac with two large, spiniform, heavily sclerotized teeth. Restricted to *Salix*. Eastern 5

4. Above, usually deep purple, sometimes bright purple, rarely coppery and then usually with purple reflections. Massachusetts and Nova Scotia to Yukon Territory and British Columbia ..... 2. *purpurea purpurea* n. sp., s. str.
Above, coppery, the reddish reflections always evident, sometimes with purple reflections that rarely are strong. Newfoundland ..... 2a. *purpurea novae-terrae* n. subsp.

5. Above, deep purple, or dark blue or blue-green and then usually with purple reflections; tibiae normally dark, their extreme apices usually obscurely pale. New England to Ohio and Georgia ..... 3. *americana americana* (Schaeff.)
Dark blue, blue-green, green, bronze, or coppery above; sometimes reddish above but then lacking the deep purple colour or reflections usual in *americana americana*; tibiae sometimes dark, sometimes partly or entirely reddish-yellow; colour of both dorsum and tibiae varying individually and geographically. Northern New England to Nova Scotia and Ontario ..... 3a. *americana canadensis* n. subsp.

6. Blackish or greenish above, lacking coppery or bluish reflections. Great Slave Lake ..... 4. *hudsonia* n. sp.
Blue or greenish-blue above. Nova Scotia ..... 5. *frosti frosti* n. sp., s. str.
Coppery above, the reddish reflections strong and sometimes tending to purple; rarely blue above. Manitoba, Alberta, Wyoming ..... 5a. *frosti remissa* n. subsp.

1. *Phratora aklaviki* (Carr)

? *Phratora interstitialis* Mannerheim, 1853: 259; Suffrian, 1858: 400.

? *Phyllodecta interstitialis* (Mannerheim), Stål, 1865: 331; Crotch, 1873: 52; Schaeffer, 1928: 47.

Phyllodecta aklaviki Carr, 1932: 192.

Length 3.9 to 4.6 mm. Usually blue-green, sometimes blue or green, above; legs blackish, the extreme apices of the tibiae sometimes obscurely pale. Antennae with the second and third segments equal in length; the fringe of the hairs on the anterior margins of the fourth, fifth, and sixth segments much more conspicuous in the male than in the female, but in the latter distinct and as well developed as in males of *purpurea* and *americana*. Pronotal base with an extremely fine, entire marginal line. Elytra with the strial punctures strongly confused on the lateral declivities and usually, but not always, arranged in regular series near the suture. Fifth segment of each tarsus more strongly widened apically and with its claws more elongate than in the other species, seven-tenths of the segment extending beyond the lobes of the third segment.

Male: Hind tibiae with their inner margins feebly concave apically, the tibiae therefore feebly arcuate; first segments of all tarsi equally dilated and subequal in width to the third segments. Copulatory organ sclerotized ventrally; the apex subtruncate at middle, oblique and very feebly sinuate on each side; internal sac with a ventral pair of elongate, arcuate plates.

Distribution.—The species occurs in the Cariboo district of British Columbia, in the basin of the Mackenzie River, and, if *interstitialis* is synonymous, in Alaska. The specimens studied are from Bowron Lake, British Columbia, and Reindeer

Depot (Mackenzie Delta), Aklavik, Norman Wells, and Great Slave Lake, NORTHWEST TERRITORIES.

Food-plant.—Salix.

Type localities.—Of *aklaviki*, Aklavik (Mackenzie Delta), N.W.T., the type in the Canadian National Collection; of *interstitialis*, Yukon River, Alaska.

Among the American species, *aklaviki* is very distinct, but it is very closely allied to *P. vulgatissima* (L.) of the Old World. In the male of *vulgatissima*, the first segment of each tarsus is slightly wider than the third segment, and the apex of the copulatory organ is very strongly sinuate on each side of the median truncation; otherwise the two species appear inseparable.

2. *Phratora purpurea purpurea* n. sp., s. str.

? *Phyllodecta vitellinae* Blatchley (*not* Linnaeus), 1910: 1161.
Phyllodecta americana Schaeffer, 1928: 46 (in part).

This, the nominate subspecies of *P. purpurea* n. sp., may be described as follows. Length 3.7 to 4.7 mm. Colour above purple or, rarely, coppery red and then usually with purple reflections; the elytra never, the pronotum rarely, with greenish reflections; legs blackish, the tibiae usually obscurely pale at their extreme apices. Antennae with the second segments four-fifths as long as the third; the fourth, fifth, and sixth segments with a fringe of long hairs on their anterior margins, the fringe moderately distinct in the male but obsolete and scarcely evident in the female. Pronotal base with an extremely fine marginal line that is restricted to the median third. Elytra with the strial punctures moderately confused on the lateral declivities. Each tarsus with three-fifths of the fifth segment extending beyond the lobes of the third segment.

Male: Hind tibiae with their inner margins virtually straight; first segments of all tarsi equally dilated and about three-fourths as wide as the third segments. Copulatory organ sclerotized ventrally; its apex rounded, frequently more broadly so than in the specimen figured; the organ much as in *americana* except for the armature of the internal sac; the armature complex but lacking prominent parts.

Distribution.—This subspecies occurs transcontinentally without geographic variation. The specimens studied are from: Framingham and Sherborn, MASSACHUSETTS; North Conway, NEW HAMPSHIRE; Essex Co., NEW YORK; Paris, MAINE; Hebron, Mt. Uniacke, and Portaupique, NOVA SCOTIA; Woodstock, NEW BRUNSWICK; Cascapedia, Brome, Sutton, and Duparquet, QUEBEC; the Ottawa district, Arnprior, Walsingham, and Turkey Point, ONTARIO; Riding Mountain Park, MANITOBA; Edmonton and Lac la Biche, ALBERTA; McBride, Dome Creek, Quesnel, Blue River, and Creston, BRITISH COLUMBIA; Norman Wells, NORTHWEST TERRITORIES; Watson Lake, YUKON TERRITORY.

Food-plants.—Populus spp. and *Salix* spp. In the Ottawa district, the subspecies is usually scarce and appears then to restrict its feeding largely to *Populus tremuloides* Michx. However, in 1946 it was very abundant just west of Ottawa at Arnprior, Ont., and fed and multiplied there without evident preference on *P. tremuloides*, *P. grandidentata* Michx., *P. balsamifera* L., and *Salix fragilis* L. At Turkey Point, Ont., the writer observed a populous colony that was restricted to *P. tremuloides* and that avoided entirely *P. balsamifera*, which was interspersed with the food-plants. The subspecies has been found on *Salix* at numerous localities, and on *P. balsamifera* at several. At Mt. Uniacke, N.S., it occurred in moderate numbers and without evident preference on intermingled *P. tremuloides* and *Salix* sp.

Holotype.— ♂, Arnprior, Ont., May 24, 1946 (W. J. Brown), on *Populus tremuloides* Michx.; No. 5925 in the Canadian National Collection, Ottawa.

Allotype.— ♀, same data.

Paratypes.—22, same data; 24, same data but from *Populus balsamifera* L., 16, same data but from *Salix fragilis* L.

P. purpurea purpurea is slightly more robust and is sometimes slightly larger than *americana americana.* However, some purple specimens of the latter can scarcely be distinguished from the former except by the genital characters. Both subspecies of *purpurea* resemble *frosti remissa* in colour.

2a. *Phratora purpurea novae-terrae* n. subsp.

Differing from *purpurea purpurea* only in the colour above; coppery red above, sometimes with purple reflections; the elytra and pronotum of a few specimens with greenish reflections in certain lights.

Distribution.—Southeastern Newfoundland.

Food-plants.—*Populus tremuloides* Michx. and *Salix discolor* Muhl.

Holotype.—♂, Gander, Nfld., July 2, 1949 (W. J. Brown), on *Salix discolor* Muhl.; No. 5926 in the Canadian National Collection, Ottawa.

Allotype.—♀, same data.

Paratypes.—26, same locality and collector, June 22 to July 2, 1949, from both food-plants; 1, Glenwood, Nfld., Sept. 4, 1949 (R. Hennigar); 1, St. John's, Nfld., July 10, 1949 (W. J. Brown).

None of the specimens are deep purple above like average specimens of *purpurea purpurea.* The series of the latter include about 260 specimens; some 10 or 12 of these agree well in colour with specimens of the present subspecies.

3. *Phratora americana americana* (Schaeffer)

Chrysomela vitellinae Rogers (*not* Linnaeus), 1856: 38 (in part); Suffrian (*not* Linnaeus), 1858: 394 (in part).
Chrysomela vulgatissima Suffrian (*not* Linnaeus), 1858: 394.
Phyllodecta vulgatissima Crotch (*not* Linnaeus), 1873: 52.
Phyllodecta americana Schaeffer, 1928: 46 (in part).
Phyllodecta americana pallipes Schaeffer, 1928: 47.

Length 3.7 to 4.3 mm. Deep purple, dark blue, or blue-green above; the greenish specimens nearly always, the blue specimens often, with purple reflections; the elytra sometimes differing from the pronotum in colour; legs normally

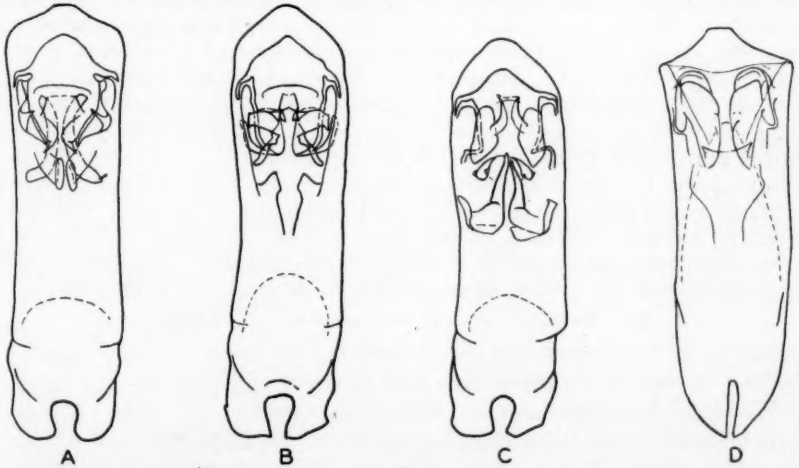


FIG. 1.—Male copulatory organ, in subdorsal aspect, of: A, *Phratora aklaviki* (Carr); B, *P. purpurea purpurea* n. sp., s. str.; C, *P. americana americana* (Schaeff.); D, *P. frosti frosti* n. sp., s. str. Drawings made from cleared specimens mounted on slides in Canada balsam.

blackish, the extreme apices of the tibiae usually obscurely pale. Antennae with the second segments four-fifths as long as the third; anterior margins of the fourth, fifth, and sixth segments with a moderately distinct fringe of long hairs in the male, the fringe lacking in the female. Pronotal base lacking a marginal line. Elytra with the strial punctures moderately confused on the lateral declivities. Each tarsus with three-fourths of the fifth segment extending beyond the lobes of the third segment.

Male: Hind tibiae with their inner margins straight; first segments of all tarsi equally dilated and about three-fourths as wide as the third segments. Copulatory organ sclerotized ventrally, rounded at apex, much as in *purpurea* except for the armature of the internal sac; the armature including a pair of large, spiniform, heavily sclerotized teeth that vary somewhat in form.

Distribution.—This subspecies occurs in and near the mountains of eastern United States. The specimens studied are from: Cornwall, Litchfield, and Stamford, CONNECTICUT; Ithaca and Oliverea, NEW YORK; Ashland Co., OHIO; Water Gap and Greentown, PENNSYLVANIA; NEW JERSEY; Glen Echo, MARYLAND; White Sulphur Springs, WEST VIRGINIA; Glencarlyn, VIRGINIA; Clayton (2,000 to 3,700 ft.), GEORGIA.

Food-plant.—Salix.

Type localities.—Of *americana*, Oliverea, N.Y.; of *pallipes*, "Ohio"; both types in the U.S. National Museum.

Schaeffer confused in his type series of *americana* all of the American species that were represented in his collection. Paratypes of *americana* from Portaupique, N.S., belong to *purpurea purpurea* and to *frosti frosti*; other eastern paratypes and the paratypes from British Columbia probably belong to the former of these, and the paratypes from Edmonton, Alta., probably belong to *frosti remissa*. The type of *americana* is a male that is purplish above and 3.9 mm. in length. Its genitalia have not been studied, but, because of the nature of its colour and other characters, there can be no doubt that its genitalia are similar to those of a topotypical specimen studied by the writer.

The description of *americana pallipes* was made from a single specimen, a male from "Ohio". This specimen has purplish elytra and a greenish prothorax; its genitalia have not been studied. The specimen is typical enough of *americana americana* except that its tibiae and tarsi and the four basal segments of each antenna are entirely pale. Because of its colour above and because a unique specimen from Ashland Co., Ohio, is typical of *americana americana*, *pallipes* is considered here a synonym of the former. It is presumed that the type of *pallipes* is abnormal for the colour of the appendages, or that it came from a population, such as occur in *americana canadensis*, that is atypical for colour.

P. americana americana may be confused with *purpurea purpurea*. The bluish colour or greenish reflections of the elytra of some specimens of the former permit their recognition without reference to the genitalia. The differences in the pronotal base and fifth tarsal segments must be used with great care.

3a. *Phratora americana canadensis* n. subsp.

? *Phyllodecta Vitellinae* Kirby (*not* Linnaeus), 1837: 216.
Phyllodecta vulgatissima Provancher (*not* Linnaeus), 1877: 664.
? *Phyllodecta americana* Schaeffer, 1928: 46 (in part).
Phyllodecta americana Schaeffer; Chagnon, 1938: 17, 1938: 305.

Length 3.4 to 4.3 mm. Like *americana americana* except for colour; the colour of the dorsum and the tibiae extremely variable in some populations, less or scarcely variable in others; the dorsum lacking the deep purple colour or

reflections of most specimens of *americana americana*; the colour of the series as follows (there is no correlation between the colour of the dorsum and that of the tibiae):—

Kazabazua, Que. (47 miles north of Ottawa, Ont.), the type series of 74 specimens: Dichromatic above; 48 specimens bronze, these infrequently with reddish reflections; 26 specimens blue-green; with very little variation in either colour form. Tibiae largely to entirely pale in 41, largely dark in 33.

Wright, Que. (10 miles north of Kazabazua), 62 specimens: Colour above as in the type series; 46 specimens bronze to feebly coppery; 16 specimens blue-green. Tibiae largely to entirely pale in 42, largely dark in 20.

St. Ours, Que. (27 miles northeast of Montreal, Que.), 41 specimens: Colour above much more variable than in the type series; 12 specimens variably coppery or bronze; 29 specimens blue, blue-green, or green, about half of these blue like some specimens of *americana americana*. Tibiae largely to entirely pale in 13, largely dark in 28.

Sutton, Que. (55 miles north of Stowe, Vt., and 60 miles southeast of St. Ours), 25 specimens: Colour above as at St. Ours; 16 specimens variably coppery or bronze, several of the coppery specimens tending toward bright purple; 9 specimens blue, blue-green, or green, the colour blue in several as in some specimens of *americana americana*. Tibiae largely to entirely pale in 6, largely dark in 19.

Brome, Que. (5 miles north of Sutton), 22 specimens: Colours above as at St. Ours and Sutton; 9 specimens variably coppery or bronze; 13 blue, blue-green, or green, about half of these resembling some of *americana americana*. Tibiae largely to entirely pale in 12, largely dark in 10.

Stowe, northern Vermont, 6 specimens: An intergrading series; 2 specimens deep purple above and with the tibiae dark as in *americana americana*; 1 specimen purple above but with the tibiae largely pale; 2 specimens blue-green above, the tibiae largely dark; 1 specimen coppery above, the tibiae entirely pale, the colour as in some specimens of *americana canadensis*.

Fredericton, southwestern New Brunswick, 13 specimens: Above, 11 specimens bronze, some with feeble reddish or greenish reflections; 2 specimens green or blue-green. Tibiae entirely pale or virtually so in all.

Cascapedia, Que. (south-central Gaspé), 13 specimens: All bronze above. Tibiae largely or entirely pale in 11, largely dark in 2.

Truro, central Nova Scotia, 195 specimens: Above, 193 specimens bronze or feebly coppery; 2 specimens blue-green. Tibiae entirely pale or virtually so in 184, about half pale in 11.

Rupert House, Que. (southern end of James Bay), 55 specimens: All bronze above, some with feeble greenish or coppery reflections in certain lights. All with the tibiae blackish except at the extreme apex.

Moose Factory, Ont. (southern end of James Bay and 85 miles west of Rupert House), 52 specimens: Similar to the specimens from Rupert House, the two series inseparable.

Walsingham, Ont. (90 miles southwest of Toronto, Ont.), 53 specimens: Above, 7 specimens variably coppery; 46 specimens green or blue-green. Tibiae blackish, at most very obscurely pale at their extreme apices.

Angus, Ont. (55 miles northwest of Toronto, Ont.), 3 specimens: All green above and with the tibiae blackish, the colour as in most of the specimens from Walsingham.

Distribution and variation.—Additional localities for *americana canadensis*

are: Woodstock and Penobsquis, New Brunswick; Berthierville, Quebec; Franconia and North Conway, New Hampshire.

In southernmost Quebec and in adjacent parts of New England, *americana* is very abundant and is extremely variable in colour. All colour forms mentioned in the description above occur in the region; the variants occur and mate together, showing that they belong to a single species. Beyond this region, colonies of the species become remarkably rare, and the variability becomes restricted. To the south, from southern New England to Georgia, coppery or bronze individuals and individuals with pale tibiae are lacking. Moreover, the populations there show, in most individuals, deep purple shades or reflections which are lacking farther north. This form is *americana americana*; because of its purple tendencies, and because its populations are similar over a very large area, the populations to the north, *americana canadensis*, are considered subspecifically distinct. The two subspecies, as shown by the small series from Stowe, Vt., intergrade in northern New England. To the east, the series from New Brunswick, Gaspé, and Nova Scotia show that individuals bluish or greenish above, or with dark tibiae, become very scarce. Such individuals become less numerous to the west, also, as shown by the series from Kazabazua and Wright, Que., in which, too, the dorsum is more strictly dichromatic. The specimens from the northwest, bronze above, with dark tibiae, and from two widely separated localities near James Bay, are remarkably constant. The two series from distant localities in southern Ontario differ from all others in having the dorsum almost always greenish and the tibiae always dark. Thus the restricted variability of the isolated Canadian colonies, i.e., of all except those from southernmost Quebec, is geographic; *americana canadensis* occurs in minor races near the periphery of its range, colour being characteristic of the populations of regions and not of individual colonies.

Food-plant.—Salix.

Holotype.— ♂ (bronze above, the tibiae bicoloured), Kazabazua, Que., Aug. 26, 1947 (W. J. Brown), on *Salix* sp.; No. 5927 in the Canadian National Collection, Ottawa.

Allotype.— ♀, same data.

Paratypes.—72, same data.

4. *Phratora hudsonia* n. sp.

Length 4.0 to 4.3 mm., the average size greater than in *frosti*. Blackish or greenish above; legs blackish, the tibiae sometimes very obscurely pale at their extreme apices. Antennae with the second segments about four-fifths as long as the third; the intermediate segments lacking special hairs in both sexes. Pronotal base lacking a marginal line. Elytra with the strial punctures never more than slightly confused on the lateral declivities. Each tarsus with three-fifths of the fifth segment extending beyond the lobes of the third segment.

Male: Hind tibiae with their inner margins varying from virtually straight to distinctly convex; first segment of each front and middle tarsus three-fourths as wide as the third segment; the first segments of the hind tarsi narrower, two-thirds as wide as the third segments. Copulatory organ as in *frosti*; not sclerotized ventrally except near the apex, the basal foramen therefore appearing to extend, in cleared mounts, to about the apical fourth; the apex truncate at middle and sinuate on each side, the truncation sometimes slightly wider than in the figured specimen of *frosti*; internal sac apically with two pairs of large, sclerotized plates, the ventral pair largely obscured in the dorsal aspect by the dorsal pair and by the articulating parts.

Distribution.—Known only from Great Slave Lake, Northwest Territories.

Food-plant.—Unknown.

Holotype.— ♂, Pearson Point, Great Slave Lake, N.W.T., July 10 to 17, 1947 (J. R. Vockeroth); No. 5928 in the Canadian National Collection, Ottawa.

Allotype.— ♀, same data.

Paratypes.—7, same locality and collector, July and August, 1946 and 1947; 1, Yellowknife, N.W.T., June, 1939.

5. *Phratora frosti frosti* n. sp., s. str.

Phyllodecta americana Schaeffer, 1928: 46 (in part).

This, the nominate subspecies of *P. frosti* n. sp., is as follows: Length 3.3 to 4.0 mm. Deep blue, usually with greenish reflections, above; legs blackish, the tibial apices and tarsi usually slightly paler. All other characters as in *hudsonia*; the apex of the male copulatory organ sometimes slightly more narrowly truncate and slightly more strongly sinuate on each side than in the specimen figured.

Distribution.—Known only from Mt. Uniacke and Portaupique, Nova Scotia.

Food-plant.—*Salix.*

Holotype.— ♂, Mt. Uniacke, N.S., June 14, 1947 (W. J. Brown), on *Salix* sp.; No. 5929 in the Canadian National Collection, Ottawa.

Allotype.— ♀, same data.

Paratypes.—58, same data, June 14 and 16, 1947.

Some of the paratypes of *americana* from Portaupique, N.S., belong to *frosti frosti*, which is named after their collector, Mr. C. A. Frost.

5a. *Phratora frosti remissa* n. subsp.

? *Phyllodecta americana* Schaeffer, 1928: 46 (in part).

Differs from *frosti frosti* only in the colour above; 54 specimens coppery above, the reddish reflections strong in all and tending to purple in some; one specimen among five from Edmonton, Alta., and one of 17 found together at Lac la Biche, Alta., blue above as in *frosti frosti.*

Distribution.—The subspecies occurs at Gillam, Norway House, Cedar Lake, and Riding Mountain Park, Manitoba; Edmonton and Lac la Biche, Alberta; Larmarie, Wyoming.

Food-plants.—*Salix*; one of the specimens from Riding Mountain Park was taken on *Populus tremuloides* Michx.

Holotype.— ♂, Cedar Lake (near The Pas), Man., July 10, 1950 (W. J. Brown), on *Salix* sp.; No. 5930 in the Canadian National Collection, Ottawa.

Allotype.— ♀, same data.

Paratypes.—19, same data.

The present subspecies resembles in colour both subspecies of *purpurea.*

References

Barber, H. S. 1940. Dejean catalogue names. *Bull. Brooklyn Ent. Soc.* 35: 1-12.

Blatchley, W. S. 1910. Coleoptera or beetles known to occur in Indiana. The Nature Publishing Co., Indianapolis.

Carr, F. S. 1932. New arctic Coleoptera. *Canadain Ent.* 64: 191-192.

Chagnon, G. 1938. Coléoptères de la province de Québec. 5. Des ateliers de l'Action Catholique, Québec.

Chagnon, G. 1938. Coléoptères de la province de Québec. *Nat. Canadien* 65: 13-23.

Chevrolat, A. 1837. Chrysomélines. *In* Catalogue des Coléoptères de la collection de M. le Comte Dejean, by P. F. M. A. Dejean, pp. 383 (or 407)-455 (or 579). Méquignon-Marvis, Paris.

Crotch, G. R. 1873. Materials for the study of the Phytophaga of the United States. *Proc. Acad. Nat. Sci. Philadelphia* 25: 19-83.

Faldermann, F. 1837. Fauna entomologica Trans-Caucasica, pars. II. *Nouv. Mem. Soc. Imp. Nat. Moscou* 5: 1-433.

Kirby, W. 1837. Insects. *In* Fauna Boreali-Americana, by J. Richardson. Vol. 4. Josiah Fletcher, Norwich, England.
Mannerheim, C. G. 1853. Dritter Nachtrag zur Kaefer-Fauna der Nord-Amerikanischen Laender des Russischen Reiches. *Bull. Soc. Imp. Nat. Moscou* 26: 95-273.
Provancher, L. 1877. Petite faune entomologique du Canada. 1, Les Coléoptères. Des Presses de C. Darveau, Québec.
Redtenbacher, L. 1845. Die Gattungen der deutschen Käferfauna nach der analytischen Methode bearbeitet. Gerold, Wien.
Redtenbacher, L. 1849. Fauna Austriaca. Gerold, Wien.
Rogers, W. F. 1856. Synopsis of species of *Chrysomela* and allied genera inhabiting the United States. *Proc. Acad. Nat. Sci. Philadelphia* 8: 29-39.
Schaeffer, C. 1928. Notes on the species of *Lina* and allied genera. *Canadian Ent.* 60: 42-47.
Sherborn, C. D. 1929. Index animalium. 20. British Museum, London.
Stål, C. 1865. Monographie des Chrysomélides de l'Amerique, III. *Nova Acta Roy. Soc. Sci. Upsal* 5: 177-365.
Suffrian, E. 1858. Uebersicht der in den Verein. Staaten von Nord-Amerika einheimischen Chrysomelin. *Ent. Ztg. Stettin* 19: 237-278, 381-400.
Westwood, J. O. (?) 1837. Journal of proceedings, November 6, 1837. *Trans. Ent. Soc. London* 2: lxvi.

Notes on the Parasitism of the Yellow-headed Spruce Sawfly, *Pikonema alaskensis* (Roh.) (Hymenoptera: Tenthredinidae)[1]

By G. A. Bradley[2]
Dominion Entomological Laboratory
Indian Head, Saskatchewan

The parasitism of the yellow-headed spruce sawfly, *Pikonema alaskensis* (Roh.), was studied in the course of investigations on the control of the sawfly in farm shelter-belts. Although some of the chemical control measures used

Table I

Emergence from Cocoons of Pikonema alaskensis (Roh.)

Species	Emergence						Percentage of Total Emergence	Emergence Period
	By Trees					Total		
	1	2	2	4	5			
Hymenoptera								
Pikonema alaskensis (Roh.)	179	135	69	28	53	464	49.4	June 3 - 21
Rhorus (Cyphanza) sp.	70	46	18	29	11	174	18.5	June 13 - 26
Lamachus lophyri (Ashm.)	48	13	7	6	4	78	8.3	June 19 - July 10
Syndipnus gaspesianus (Prov.)	29	14	16	14	2	75	8.0	June 12 - 20
Smicroplectrus velox Wly.	4	32	13	15	9	73	7.8	June 19 - July 10
Endasys (Endasys) pubescens (Prov.)	21	2	2	2	4	31	3.3	June 19 - July 3
Syndipnus rubiginosus Wly.	8	5	3	2	—	18	1.9	June 21 - July 7
Mastrus argeae (Vier.)	—	4	1	2	—	7	.7	June 19 - 26
Erromenus (Aderaeon) bedardi (Prov.)	1	—	—	—	2	3	.3	June 19
Olesicampe pikonemae Wly.	—	2	—	—	—	2	.2	June 13
Bethylidae (2 species: undetermined)	—	11	—	3	—	14	1.5	June 24 - July 15
Diptera								
Bessa harveyi (Tns.)	—	1	—	—	—	1	.1	June 19
						940		

[1]Contribution No. 6, Division of Forest Biology, Science Service, Department of Agriculture, Ottawa, Canada.
[2]Agricultural Research Officer.

against the sawfly destroyed its parasites, others did not. A knowledge of the parasites and their abundance in the study area became necessary. Since most of the parasites known to attack the sawfly emerge from the cocoons, this stage of the host was investigated first.

Five trees in the sawfly-infested shelter-belt at Dahlton, Sask., selected as being typical in size and in severity of infestation of the shelter-belt as a whole, were prepared in the summer of 1949 for cocoon collection. In order to obtain cocoons of one season only, the soil was removed to a depth of 6 inches from beneath the canopy of each tree and replaced with soil free of cocoons. Later in the season after the sawfly larvae had entered the ground, the cocoons were recovered by sifting the soil. The cocoons were placed in screened boxes in the ground until early June, 1950, when they were brought into the insectary for emergence of the adult sawflies and parasites.

The species of parasites and the relative abundance of each are shown in Table I.

High mortality occurred among both the parasitized and unparasitized sawflies, apparently caused by mechanical injury during the separation of the cocoons from the soil.

The author is indebted to Mr. G. Stuart Walley and Mr. A. R. Brooks of the Systematics Unit for the identification of the ichneumonid and dipterous parasites respectively.

The Phenomenon of Autonarcosis in a Parasitic Wasp

By RICHARD L. DOUTT
Division of Biological Control, University of California, Albany

In the laboratory culture of parasitic Hymenoptera it is a common practice to collect the adults from the large emergence cages into glass tubing with a power-driven aspirator. This glass tubing has an absorbent cotton plug at one end and the aspirator cork at the other. Depending upon the characteristics of the species being handled, from 100 to 400 individuals may be collected without impairment into a single tube before the aspirator cork is removed and replaced with another plug of absorbent cotton. The cotton plugs are then tightly fitted into each end of the tubing, and the volume of air space remaining between them amounts to approximately 38 ml. Parasites confined in this manner may be stored for brief periods if fed honey and held at cool temperatures. They are commonly packed in this fashion for transport to experimental field plots.

It was noticed that adults of *Tropidophryne melvillei* Compere, a parasite of *Planococcus citri* (Risso), frequently exhibited an abnormal behaviour after being collected in these tubes. The movement of the wasps gradually slowed and finally stopped. Many individuals clung to the glass walls of the tubes until a sudden jar or contact with another wasp dislodged them. Most of the fallen individuals slowly and somewhat spasmodically moved their appendages, although a few were able to crawl feebly about for a few minutes. The entire population soon became completely immobilized. The symptoms closely resembled the pattern induced by a mild anaesthetic, such as ether or carbon dioxide. A very strong odor similar to that of grated coconut meat was present in the tube. Without change of air the wasps very slowly revived and in a few hours were behaving normally.

This phenomenon of autonarcosis does not occur if only a few adults are collected into a tube, but becomes evident when more than 120 adults are confined

in the volume of 38 ml. Thus the phenomenon is apparently associated with density. This density must be calculated, however, on the basis of the number of individuals per unit volume of stagnant or tainted air. If the air in the collecting tube is not allowed to stagnate, but is constantly replaced by fresh air the symptoms of autonarcosis do not appear.

The rate at which the insects succumb to autonarcosis seems to be directly associated with the density. For example, a comparison was made of the reactions of adult parasites confined at various densities in the 38 ml. volume of a standard collecting tube at 82°F. It was found that a concentration of 100 adults or less did not become immobilized; 120 adults became quiescent with only a few being knocked down; 135 to 150 adults were completely immobilized in 20 minutes; test lots of 200 adults confined under the same conditions succumbed to autonarcosis within periods ranging from 12 to 17 minutes; 300 adults similarly confined were knocked down within 10 minutes; and 400 adults succumbed within 6 to 7 minutes.

The stupefying agent also affects other insects when confined with the *Tropidophryne*. At different times such insects as *Drosophila*, *Leptomastix*, *Anagyrus*, and *Leptomastidea* have been purposely confined with *Tropidophryne* undergoing autonarcosis, and these other insects reacted in much the same manner as the *Tropidophryne*. Stupefaction of such insects occurs at densities of *T. melvillei* below the threshold of autonarcosis for that species. For example, autonarcosis does not occur when 100 *Tropidophryne* are combined in a standard tube, but stupefaction of *Anagyrus kivuensis* Compere will occur if this species is present.

Recovery from the effects of autonarcosis occurs after a period of approximately 3 hours. Recovery is not rapid and some individuals are much slower to regain the normal behaviour pattern than others. During the recovery period there is considerable flexing of the wings and the wings are repeatedly rubbed with the hind legs.

A population of *Tropidophryne* which has undergone autonarcosis and recovery will not again exhibit autonarcosis even though subsequently confined at a greater density. Apparently the glands producing the volatile chemical are not replenished. This seems to be true since susceptible insects of other species confined with these depleted *Tropidophryne* do not become stupefied.

There seems to be no ready explanation for the occurrence of this phenomenon. So far as is known it has never been observed in any of the many other species of Hymenoptera which have been cultured in the past in California insectaries. It occurs under conditions which would never be present in nature and consequently does not seem to be an adaptation for protection or defense, although it may possibly be an atavism of such a device. Until a suitable explanation is available this phenomenon of autonarcosis remains merely as a curious response to initial crowding in stagnant air, and a reaction which is nonrecurrent during the life of the individual.

THE RUNGE PRESS LIMITED, OTTAWA
Mailed: Monday, May 28, 1951